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# IMPLEMENTATION OF COMPUTER TECHNOLOGIES IN DESCRIPTIVE GEOMETRY TEACHING: SURFACES OF REVOLUTION

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**Radovan B. Štulić, Jelena T. Atanacković**

Faculty of Technical Sciences, University of Novi Sad
E-mail: sdrulias@EUnet.yu, mja@nspoint.net

**Abstract**. *The proper estimation of computer technologies is very important when computers are to be implemented in the educational process. Otherwise, if not implemented properly, the quality of students' education may be seriously imperilled.*
*This is crucial when Descriptive geometry (DG) is the matter; the discipline that develops and improves the students' spatial visualisation ability (SVA). Unfortunately, nowadays, there is a tendency that some educators, mostly non- geometricians, being destitute of profound knowledge of DG, and not fully understanding the fundamental importance of DG, find themselves involved in computerisation of DG, using various CAD programs and thus, force students to (computer aided − CA) draw already well known standardized objects and consequently train their capabilities typical for draughtsman.*
*In this paper we, propose how and to which extent the computerisation of DG should be carried out. The previous has been governed by the criteria of facilitating students' comprehension of spatial relationships, orientation and visualisation.*
*We have developed the procedure for the representation of surfaces of revolution (SOR) and their shades and shadows on planes. What is to be emphasised on the matter is that each CA approach to DG teaching should follow the traditional DG reasoning and the step-by-step acquisition of fine solution, offering students the possibility of gradual process of visualisation.*

**Key words**: *surface of revolution, contour line, shade, shadow, computerisation of Descriptive geometry teaching.*

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## 1. INTRODUCTION

Lately, the deterioration of students' SVA has been noticed all over the world. The causes of this may be sought also in the fact that curricula of DG, both at secondary and University level of education, have been reduced [1]. Modern technologies, such as a computer technology, gradually push out the 'traditional' courses, introducing, as is nowadays popularly said, 'modernised' teaching. Unfortunately, such changes are sometimes imprudent, without clear vision whether they enhance either the teaching process or students' abilities and capabilities. The previous statement can be, to a certain extent, understood if we accept the fact that the creators of such computer technologies, who promoted them in classrooms, are not interested in the educational process itself, but in selling their software [2]. The fundamental problem of such software, particularly while considering that the subjects that develop students' SVA (such is DG) are taken into account, is firstly, that they are basically aimed, not at education, but at practical engineering, i.e., engineering design, and secondly, that they are not created by people involved in education who are not fully instructed in DG as well as in problems of SVA development.

A student that is about to study projections and is getting used to reconstruct 3D properties of objects represented on 2D image mostly does not benefit from such software. The image instantly rendered on the screen is for him/her a kind of a pattern which does not point out geometrical properties of the represented object and thus such image is not much of a use to him/her.

The fact that there is a real possibility of taking over DG by educators being neither geometricians nor interested in research in this field of study is a great disadvantage for the students and their proper amelioration of SVA (this has already happened at one of the Departments of Mechanical Engineering in Novi Sad). Thus, we are of the opinion that everyone involved in geometry and graphics should start the research on the ways of the proper use of computers in DG teaching and implementation of particularly created computer software for this purpose. Only educators fully understanding DG and spatial visualisation can with adequate responsibility introduce computers in the teaching process as SLABY at the Princeton University [3] suggests that the use of computers in courses of DG and graphics should be introduced after the students have worked with their eyes, minds and hands on the theory of DG through drawing on the paper and model making. Such experience will enable them to feel the geometry which is not possible nearly by punching the keys on a computer. Only DG educators fully instructed at the theory of DG and graphics can make the right balance between necessary theoretical bases and exercises that follow, as a precondition for all well done education reforms. Numerous reforms in graphics teaching, as CHEN at Beijing University of Aeronautics and Astronautics states, produced great rises and falls of quality of teaching not only in China, but in USA as well, with an enormous waste of time and effort [4].

## 2. A NEED FOR COMPUTERISATION OF DESCRIPTIVE GEOMETRY

Computers, when used in an appropriate way, may become a powerful tool and a good 'assistant' for advancement of educational process. Most probably each of us, involved in DG teaching, has been faced with the problem of a short class. When dealing with geometrical treatment of objects (from a point to a surface) in orthogonal projections, a 3D representation – a sketch of the matter is always welcome.

For instance, when we deal with the representation of SOR, we restrict our study to a pair of orthogonal projections, one of them giving an axis of a SOR in true size. In this case, the use of the method of auxiliary touching spheres gives the solution: the visibility dividing line (VDL) of the surface for the corresponding view direction is solved by the use of rulers only and its corresponding projection – a contour line, by the ruler and the compasses. However, for the proper explanation of the method, it is essential to provide a spatial representation of a SOR with all necessary elements. On that spatial representation, the procedure of introducing a touching sphere, its touching circle with a SOR, visibility of points of the sphere etc, is more obvious then in the orthogonal projection that shows the axes in true size and the system of circles- parallels of the SOR together with the great circle of the sphere (VDL of the sphere) in a projecting position.

In order to draw this sketch on the blackboard, on which we shall give the necessary explanation, we 'lose' certain time. Undoubtedly, we can prepare it in advance, and show it as an already drawn one, using the overhead projector. However, any already made drawing, for an observer who has just started learning, either geometrical properties or ways of representations of objects is not much of a use. Therefore, it is much more appropriate to use a computer and a particularly created program which performs the step-by-step procedure, for obtaining the drawing (Fig. 1):

1. the representation of the surface and the introduction of projection rays,
2. the choice of circle-parallel of the surface
3. the determination of the centre of the touching sphere at the circle parallel and the representation of the sphere

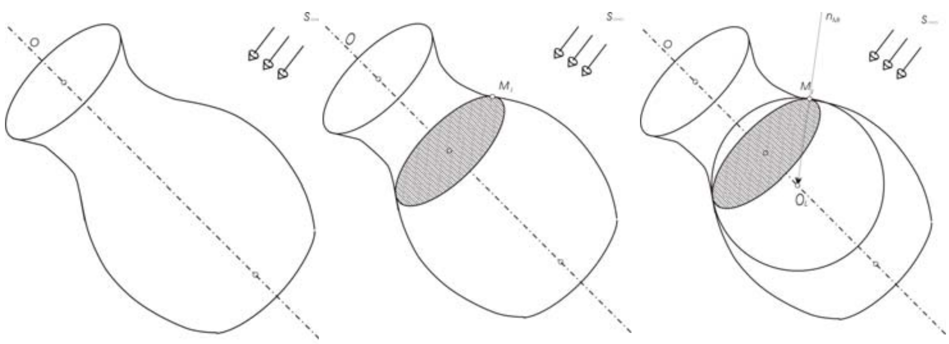

Fig. 1. SOR, arbitrary circle-parallel and its touching sphere at that circle parallel

The final step is the representation of the great circle on the sphere which is its VDL for the given projection rays and the solution of the visibility dividing points on their common circle–parallel (Fig. 2):

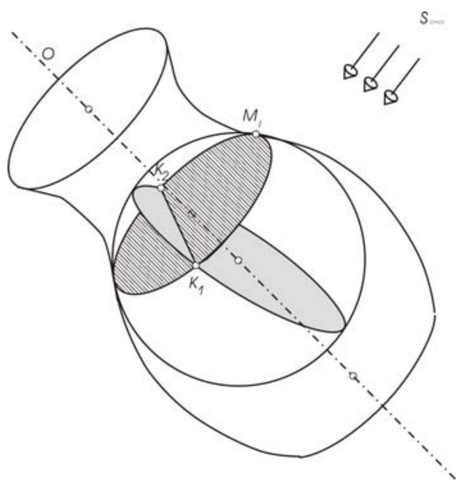


Fig. 2. Visibility dividing points of SOR

This program can be performed with totally defined parameters, that is, already defined surface, its arbitrary circle-parallel and projection rays (or rays of illumination). It means that for this purpose i.e., the explanation of the method, there is no need to analyse a totally arbitrary case which can give non-real solutions. At this point of the lesson, when we are introducing the problem, the simplest case and the most vivid image is the most suitable and the most useful one.

On the other hand, the representation of SOR as well as its VDL, illumination dividing line (IDL), shades and shadows is by no means an easy procedure and due to the lack of time we can merely mention it. In this case a computer is really a powerful additional means since the obtaining of exact solution of the SOR representation with its VDL, IDL, shades and shadows becomes easy. Moreover, the same reasoning used for simpler surfaces, that we teach in details, and thus, familiar to students (such are: pencil-line generated surfaces: cylinders, cones, pyramids, prisms) can be applied in the same way.

When a shadow of a SOR appears on several planes, it is both convenient and advisable to solve only the characteristic points of the shadow, the points where the shadow passes from one plane to another. In that way, we avoid the randomisation of points, and facilitate both students' perception and comprehension of the solution.

A computer program should therefore provide the procedure of the step-by-step tracing of this characteristic points. It means that the views of the characteristic-projecting position of the planes are to be represented as well. The reverse ray of light directly solves those points. In our CA program for the determination of VDL, IDL and contour lines of all projections we use polar cylinders of SOR [5]. The IDL of a general SOR is a space curve which generates the illumination cylinder of the surface. Planes in the umbra are plane sections of that cylinder. When the SOR is treated by its polar cylinder then at each point of the IDL, its tangent to do IDL is also known. Locally, at each point of the IDL, oscillatory plane of the space curve is affine to the shadow on the plane. In other words, tangent to the IDL, with respect to its piercing point through to the plane of the shadow, is transformed (affinly) to the tangent of the shadow.

In the Figure 3. as the first step of the CA program we represent an oblique projection of SOR with vertical axis, ray of light and corresponding IDL of the surface.

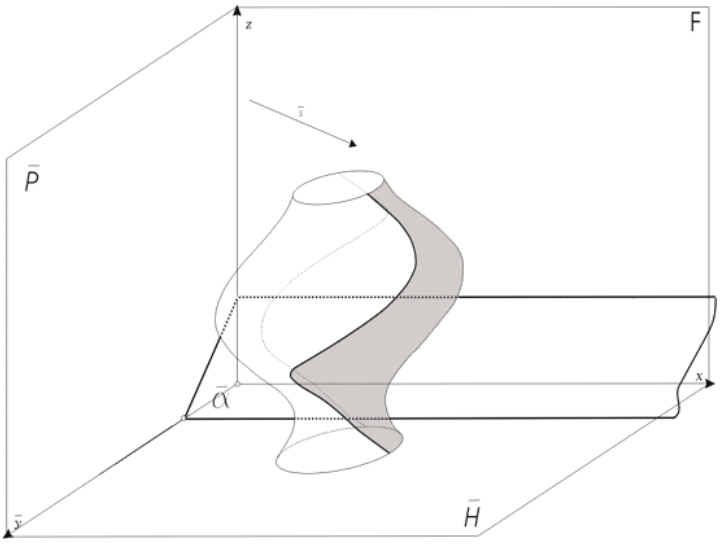


Fig. 3.

In the next step (Fig. 4.) the side view is introduced in which the first and the second trace of the plane α, being loci of characteristic points of the shadow, are projected in the points and the reverse ray of light gives the solution.

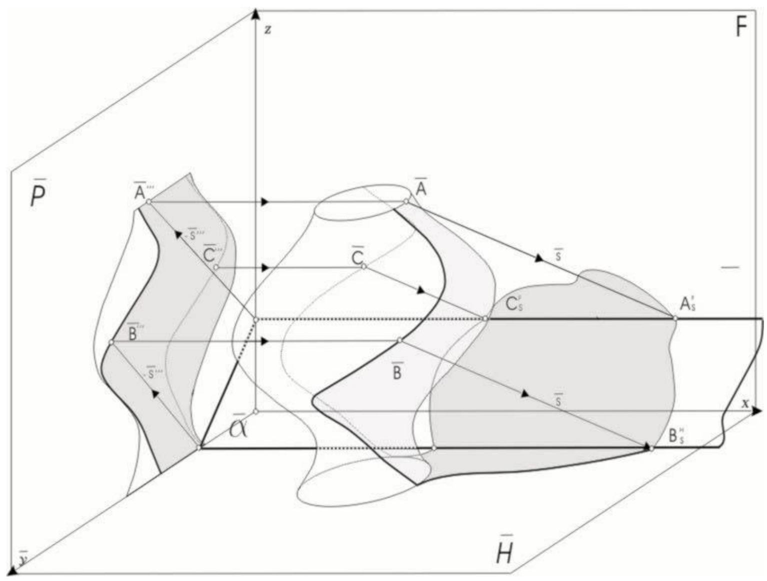


Fig. 4.

Finally, in the Fig. 5. tangents to the shadow on the planes on which the shadow spreads (horizontal plane H, sloped plane $\alpha$, and frontal plane F), by the use of (local) affinity between points of IDL and the shadow are determined.

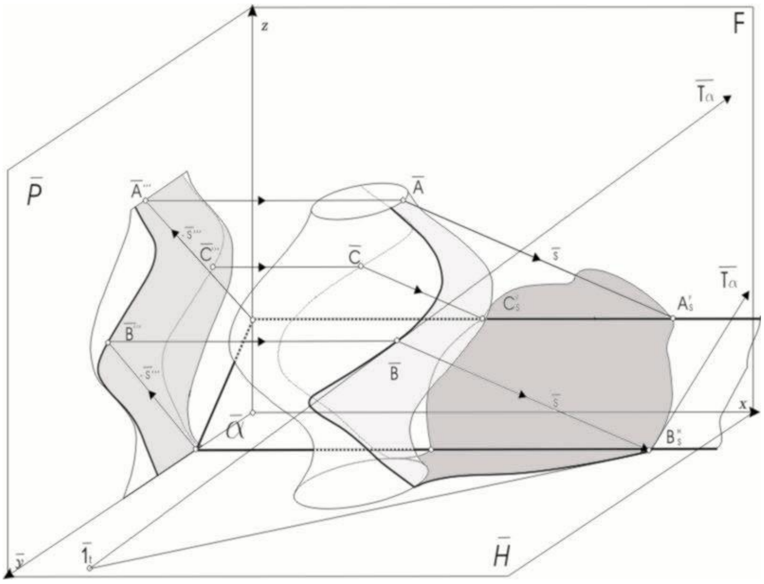

Fig. 5.

## 3. CONCLUSION

It is very important to recognize that the implementation of CA teaching of DG is very delicate meaning that the introducing of computers into educational process must be very carefully and prudently carried out. According to the results of the researches presented in [6] and [7] the improvement and development of students' SVA is enhanced by DG courses and even more courses that stress hands-on sketching and drawing (eye-to-hand coordination) tend to improve spatial skills more than courses that stress CAD methods [8]. Therefore, CA teaching should be introduced as an additional means which effectively and swiftly gives exact solutions for various representation of objects and in that way offers the possibility for enrichment of lessons by more examples of the method which otherwise, due to the lack of time, could not even be mentioned. The interested reader should seek another interesting proposal for implementation for CA teaching of DG as a supplementary means to traditional one given in [9].

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# IMPLEMENTACIJA KOMPJUTERSKE TEHNOLOGIJE U NASTAVI NACRTNE GEOMETRIJE: ROTACIONE POVRŠI

**Radovan B. Štulić, Jelena T. Atanacković**


*Prilikom implemenentacije kompjuterskih tehnologija u obrazovni proces veoma je važno dobro proceniti njihov značaj, kako kvalitet obrazovanja studenta ne bi opao.*

*Ovo je krucijalno u slučaju nacrtne geometrije (NG); discipline koja razvija i poboljšava sposobnost prostorne vizuelizacije (SPV) kod studenata. Nažalost, u današnje vreme, uočena je tendencija da se neki predavači, koji nisu ″geometričari″, i stoga lišeni temeljnog poznavanja NG kao i razumevanja njenog suštinskog značaja, upuštaju u kompjuterizaciju nastave NG, korišćenjem različitih CAD programa. Ovakvim nastavnim programima najčešće se od studenata zahteva da (kompjuterski) crtaju već poznate standardne elemente i na taj način treniraju se sposobnosti tipične za tehničke crtače.*

*U ovom radu predlažemo na koji način i do koje mere bi kompjuterizaciju nastave NG trebalo sprovesti. Osnovni kriterijum kojim smo se rukovodili bio je da se studentima olakša razumevanje prostornih odnosa, prostorne orijentacije i procesa vizuelizacije.*

*U radu smo razvili proceduru za predstavljanje rotacionih površi (RP) i njihovih sopstvenih i bačenih senki. Ono što je važno naglasiti je da bi svaki kompjuterski podržan pristup nastavi NG, trebalo da prati tradicionalno NG rezonovanje i step-by-step dobijanje rešenja, na taj način nudeći studentu postepen proces vizuelizacije.*


Ključne reči: *rotaciona površ, kontura, sopstvena i bačena senka i kompjuterizacija nastave nacrtne geometrije*